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Annual Review 1987/88

Energy Conservation and Renewable Energy Research, Development and Demonstration Program

Alberta
ENERGY
Scientific and Engineering
Services and Research Division

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Energy Conservation and Renewable Energy Research, Development and Demonstration Program

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Director's Report

Energy conservation and renewable energy research projects supported by the Alberta/Canada Energy Resources Research Fund (A/CERRF) are continuing to produce results that help Albertans save energy* and develop their alternative energy resources. At the same time, innovators and entrepreneurs are being afforded opportunities to demonstrate their skills and establish themselves as providers of unique and valuable services and products.

Since 1977, when the Energy Conservation and Renewable Energy Research, Development and Demonstration Program began, more than 60 projects have been supported on a wide variety of topics, ranging from solar and wind energy research, to energy conservation in the oil and gas industry, to fusion energy studies.

In 1983/84, the emphasis shifted to three general subject areas, each of which became a subprogram having several concurrent projects under way. These subprograms were:

Energy Conservation in Buildings;

Wind Energy; and

Waste Heat Recovery/Low Temperature Heat Utilization.

This year, activities in these subprograms began to wind down and two new subprograms were initiated: Energy Conservation in Industry and Hydrogen Technology Research. The latter, in particular, may represent a major focus over the next year or two.

Altogether, 14 research projects were under way this year, plus participation in a technology transfer project supported by A/CERRF. The latter continued to make research results available to hundreds of energy researchers. Funding contributions from A/CERRF totalled $393 645.

Energy Conservation in Buildings

This year, five projects were continued from 1986/87, and a new three-year Energy Conservation in Housing project was launched at the University of Alberta. Two projects were completed, while three others and the University of Alberta project will continue into 1988/89.

Results from the two completed projects should be of interest to most Alberta communities. In one, the energy savings potentially available from using low emissivity ceilings in indoor ice arenas were demonstrated at ice rinks in Edmonton and Medicine Hat. At the Edmonton arena, where ice is present year-round, there was a 41 per cent drop in the operation time of ice-making compressors. This represented sufficient electricity savings to produce a payback period of slightly less than two years. For the Medicine Hat arena, however, the payback period was over eight years, principally because electricity rates are approximately half those of Edmonton and ice making occurs only 10 months of the year. Despite these divergent results, it is expected that the compressor operation time could be reduced by 25 to 30 per cent in most Alberta arenas following installation of low emissivity ceilings.

Indoor swimming pools represent another type of recreational facility in which energy savings are likely, but the challenge is made greater by having to find the right balance among air temperature, pool water temperature and humidity level. As demonstrated at a pool operated by the City of Calgary, a programmable controller can be used to good advantage and, in this case, it paid for itself in slightly more than two years by lowering the demand for purchased natural gas. This was accomplished by continuously operating the supply air and exhaust air fans, maintaining the pool air temperature at 29.5°C (85°F) and controlling the relative humidity to a maximum of 60 per cent.

Wind Energy

The services being provided by the Lethbridge Wind Research Test Site continue to be of considerable value in helping to create a viable wind energy industry in Alberta. This year, eight water-pumping wind turbines and two solar-powered water pumpers were tested for performance, reliability and overall efficiency. In addition, a deep well simulator was built and tested. It will allow testing of water pumpers at the equivalent of much greater depths and, therefore, provide performance data relevant to conditions under which machines would be expected to perform in overseas markets. In recognition of the valuable service this test site is providing, financial assistance was extended another year.

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* Several projects were initially identified as a result of energy audits performed by Alberta Energy. For more information on energy audit services, contact: Energy Conservation Branch, Alberta Energy, 2nd Floor, 10010 - 106 Street, Edmonton, Alberta T5J 3L8, Telephone: (403) 427-5200.

Waste Heat Recovery/Low Temperature Heat Utilization

Five projects in this subprogram were under way this year. Two were completed, one was terminated and two will continue into 1988/89. At the meat-packing plant of Lakeside Feeders, near Brooks, a waste heat recovery system was installed in 1986 and monitored throughout most of 1987. The recovered heat was used to preheat the process water before the final temperature was achieved in a natural gas-fired boiler. Previously, the boiler supplied all the heat. It was found that purchases of natural gas valued up to $31 000 a year could be avoided. Also, hot water was more readily available than in the past. This resulted in greater plant productivity. For this particular installation, the payback period was only 15 months. While these impressive results might not occur in every instance, it was strongly recommended that similar waste heat recovery systems be tried in dairies, breweries and food-processing operations.

Commercial laundries represent another type of operation capable of generating considerable quantities of waste heat, in this case in the form of hot water discharged from washing machines. At two such facilities in Calgary, a waste heat recovery system was installed, along with a water reuse system and filters to protect the heat recovery system from becoming fouled with cloth fibres. At one of the laundries, the demand for natural gas, used to heat process water, subsequently declined by 38 to 50 per cent, and water consumption was down by 19 to 23 per cent. Savings at the other laundry were similar, resulting in payback periods of four to five years. It was concluded that $800 000 could be saved annually in Alberta if waste heat recovery systems were used in existing commercial, hospital, hotel/motel and coin-operated laundries.

Energy Conservation in Industry

This year, in response to interest expressed by companies representing Alberta's resource industries, a new program was launched with the objective of developing energy technologies having good potential for economic benefits within five to 10 years. While nine proposed projects were considered for funding, subsequent financial constraints allowed only one to proceed. It deals with the feasibility of energy recovery from municipal wastes and is likely to be relevant to smaller Alberta cities and local manufacturers of heat recovery equipment. This project is due for completion in 1988/89.

Hydrogen Technology Research

This year, the first project in what may be a major subprogram over the next two years was begun in hydrogen research. There is considerable merit in conducting this research because the production and use of hydrogen will become more important as the demand for synthetic crude oils increases. This is expected to be in response to a decline in crude oil production from conventional sources. This is the immediate reason for launching a hydrogen technology research subprogram, but in the long term, hydrogen may also represent a potential solution to environmental problems associated with fossil fuels. To initiate this subprogram, a survey was made of Alberta hydrogen producers and consumers to determine those aspects of hydrogen technology which are in need of further research. The results of this investigation are expected to lead to several research projects next year.

Technology Transfer and Dissemination

To date, 14 technology transfer booklets describing 34 energy conservation and renewable energy projects have been published. They were distributed to more than 300 energy researchers, government agencies, energy companies and technical libraries.

Program Overview

With the completion next year of most of the current energy conservation research projects, this phase of the program will wind down and be replaced with new areas of investigation. While the program is still committed to encouraging the wind turbine industry and research related to housing, it is expected these new areas of investigation will be as exciting and important as earlier subprograms in providing new directions for Alberta's energy future.

J.K. Kleta
Director
Energy Conservation and
Renewable Energy Research

Introduction

Funding for the Energy Conservation and Renewable Energy Research, Development and Demonstration Program is provided through the Alberta/Canada Energy Resources Research Fund (A/CERRF). Contractors who perform actual research work also make financial contributions to individual projects.

A/CERRF was established as a result of the 1974 agreement on oil prices between the federal government and the oil-producing provinces. The federal government pledged increased funds to strengthen and diversify Alberta's economy, including $96 million for energy-related research projects. Responsibility for applying and administering the fund rests with the A/CERRF Committee, comprising senior Alberta and federal government officials.

During 1987/88, research activities focused on three main research areas, namely:

Energy Conservation in Buildings;

Wind Energy; and

Waste Heat Recovery/Low Temperature Heat Utilization.

Also, work in two new subprograms was initiated. The new research areas are:

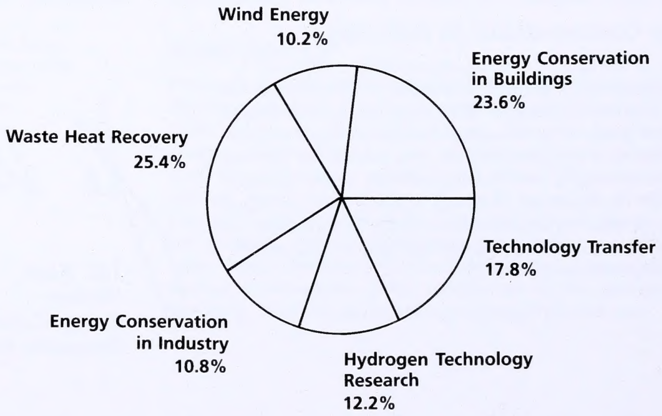
Energy Conservation in Industry; and

Hydrogen Technology Research.

The following section, Review of Program Projects — 1987/88, provides detailed information about individual projects and their achievements, while the financial aspects of past and present projects can be found in Appendix A.

The portion of program expenditures provided by A/CERRF this year amounted to $393 645. It was divided among the five subprogram areas and technology transfer as shown in Figure 1.

Figure 1: A/CERRF Energy Conservation and Renewable Energy Program Funding Distribution (1987/88)



	Funding ($)	Percentage (%)
Energy Conservation in Buildings	93 173	23.6
Wind Energy	39 996	10.2
Waste Heat Recovery	100 117	25.4
Energy Conservation in Industry	42 568	10.8
Hydrogen Technology Research	47 874	12.2
Technology Transfer	69 917	17.8
TOTAL	**393 645**	**100.0**

Review of Program Projects — 1987/88

The following project summaries describe the objectives and principal results of investigations partially funded by A/CERRF and carried out during 1987/88 in the Energy Conservation and Renewable Energy Research, Development and Demonstration Program. For additional information, contact the Director of Energy Conservation and Renewable Energy Research or the appropriate contractor(s).

Energy Conservation in Buildings

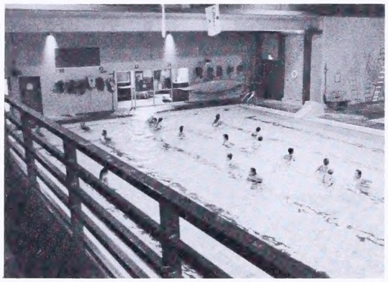
Energy consumption in building systems accounts for 35 per cent of total energy demand in Canada. Approximately half of this is used to heat residential buildings, while much of the remainder is used to operate heating, ventilation and air-conditioning systems in offices, recreational facilities, institutional buildings and other types of structures.

Since 1978, 39 research, development and demonstration projects related to energy conservation in buildings have received financial support from A/CERRF.

This year, two projects were completed, three were continued into 1988/89 and one new project was initiated. All six are described in the following section.

Energy Conservation in Public Swimming Pools

IBI Group, Calgary



Installation of a programmable controller to regulate air temperature, humidity and the pool water temperature at the Renfrew Pool in Calgary resulted in lower natural gas consumption and annual savings of $10 700.

(Photo courtesy of IBI Group)

At each of the 11 indoor swimming pools operated by the City of Calgary, natural gas costing $29 000 is consumed annually.

To help lower these costs, an energy audit was performed on Renfrew Pool, which was regarded as typical of the group. Subsequently, several measures were implemented to control air temperature, humidity and the pool water temperature, with the objective of lowering energy consumption.

This goal was accomplished by using a microprocessor-based programmable controller to continuously operate supply air and exhaust air fans, maintain the pool area air temperature at 29.5°C (85°F) and control the relative humidity to a maximum of 60 per cent.

After the control procedure was implemented, natural gas consumption was monitored for one year and compared with records of gas use for one year before the system was installed.

It was calculated that annual energy savings amounted to 4 110 GJ, estimated to be worth $10 700. This resulted in a payback period of 2.2 years, based on capital costs of $23 590 for the control system.

The project has been completed.

Swimming Pool Dehumidification Demonstration

Klass Mechanical Enterprises Ltd., Calgary

The performance of a conventional air exchange system is being compared with that of a heat pump dehumidification system at the University of Lethbridge Aquatic Centre, with particular emphasis on energy consumption and opportunities to use waste heat within the facility.

The two dehumidification systems were operated and monitored independently under similar ambient conditions throughout the year. Preliminary data analysis indicates that during cool weather, less energy is consumed when mechanical dehumidifiers are used in place of outdoor air for dehumidification. Also, when outdoor air is used, energy consumption increases as the outside air temperature decreases.

Demonstration of Low Emissivity Ceilings in Alberta Arenas

Sunton Engineering Ltd., Edmonton

In the first year following installation of a low emissivity ceiling at the Londonderry Arena in Edmonton, there was a 41 per cent decrease in the refrigeration compressor operation time. Annual electricity cost savings amounted to $27 509, representing a payback period of 1.9 years.

(Photo courtesy of Ian Biggar)

It has been demonstrated in some Ontario and Quebec ice arenas that installation of an aluminized ceiling material above the ice surface can lower the radiative emissivity of heat from the ceiling to the ice and reduce refrigeration energy requirements by as much as 33 per cent.

To determine whether similar results were possible in Alberta's climate, low emissivity ceilings were installed in the Londonderry Arena in Edmonton and the Civic Centre Arena in Medicine Hat. Soon after installation, it was observed that the refrigeration compressor could be operated for less time to maintain the same ice conditions as before. This was the direct result of less heat reaching the ice. At the Londonderry Arena, where energy-conserving lighting is used, the reflective characteristics of the ceiling made it possible to reduce the power setting of the lamps without lowering the light level.

Energy consumption (as indicated by the ice plant compressor operation time) was monitored for one year and the results were compared with records for the year before the ceilings were installed. At the Londonderry Arena, there was a 41 per cent drop in compressor operation time, amounting to annual savings of $14 482 for electricity. When compared with a cost of $27 509 to install the ceiling, a simple payback period of 1.9 years was calculated.

At the Civic Centre Arena, a 28 per cent reduction in compressor operation time was measured. This was equivalent to annual savings of $3 573, or a simple payback period of 8.3 years for capital costs of $29 500.

It was concluded that the potential economic effect of using low emissivity ceilings is a function of:

- the length of time the arena operates;
- the cost of electricity;
- the type and capacity of the refrigeration plant; and
- whether or not energy-saving lighting is used in an arena.

It was concluded that in most Alberta ice arenas, it should be possible to reduce compressor operation time by 25 to 30 per cent following installation of low emissivity ceilings.

The project has been completed. One copy of the final report is filed at the Alberta Energy Library (see Appendix B).

Demonstration of Free Cooling in Building Humidification Systems

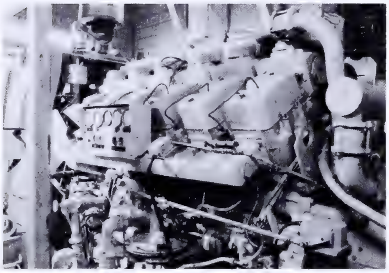
Safronek Pomeroy & Associates Ltd., Calgary

During the summer months in Canada, air-conditioning systems are commonly used to help achieve a comfortable indoor environment. The refrigeration components of most air-conditioning systems, however, can consume substantial amounts of energy over a typical cooling season. An alternative approach, which is being investigated in this study, is to obtain cooled air by passing air across water-soaked pads or water sprays.

The use of existing spray coil and cellulose media components of air-conditioning systems at the University of Lethbridge was monitored from May 1 to October 31, 1987 to determine the number of days in each cooling season that evaporative cooling could be effective. It was found that direct evaporative cooling reduced the operation time of the refrigeration system from 1 100 hours to 522 hours. This represented a cost saving of $12 400 for one cooling season and a payback period of approximately five years for this installation.

Peak Electrical Demand Reduction Through Co-generation

Cheriton Engineering Inc., Edmonton



The operation of an existing 1MW gas-fired co-generator at the University of Lethbridge has been studied since 1985 to determine the cost effectiveness of using the unit, and others like it, to reduce peak demands for electricity.

The emergency generators present in many large buildings are seldom, if ever, used for their intended purpose. However, they could be employed regularly to generate electricity and thereby reduce the peak demand for power supplied by local utility companies. Also, the heat produced by generators could be recovered, thereby reducing the purchased fuel requirements of the building. To determine the advantages and disadvantages of this concept, the operation of an existing 1 MW gas-powered co-generation unit at the University of Lethbridge has been studied since 1985.

This year, monitoring and data collection were continued until the end of December. The final report is expected to be completed early next year.

Energy Conservation in Housing

University of Alberta, Edmonton

This year, a radiant floor-heating system was installed in the basement floor (followed by concrete, as shown here) and the joist space between the basement and the main floor of one of the test houses at the Alberta Home Heating Research Facility.

Four housing-related technologies are being studied over three years by the Department of Mechanical Engineering, University of Alberta, using the existing test houses of the Alberta Home Heating Research Facility. The four technologies are:

- an hydronic, radiant floor-heating system;
- a gas-fired absorption heat pump;
- passive ventilators for use in airtight homes; and
- the measurement of moisture migration through typical structural components of a test home.

This year, the radiant floor-heating system was installed in the concrete basement floor and in the joist space between the basement and the main floor of one of the test houses. The basement floor-heating system was installed on top of RSI 0.88 (R5) rigid insulation. Measurements were begun of total energy consumption, radiation gain through south-facing windows, air stratification and air temperature as an indication of comfort level.

A literature search revealed that two types of natural gas-fired heat pumps (absorption units and engine-driven types) are being developed for use in homes, but they are currently unavailable for independent testing because they are being redesigned. Attempts are under way to obtain the redesigned units when they become available.

As an alternative to using exhaust fans or heat recovery ventilators in airtight homes, passive ventilators equipped with dampers may prove to be both satisfactory and cost effective. In this study, 15-cm diameter pipes were installed in south-facing basement walls of five test houses at the Alberta Home Heating Research Facility. Each pipe was equipped with an electrically operated damper. The damper in one house was opened and closed at set intervals while the dampers in the other four houses were kept open. Measurements were made of ventilation rates and work was initiated to develop a control strategy.

To measure moisture migration through the walls of a home, two test panels (one each on the north and south walls) comprising drywall, vapour retarder, insulation, exterior sheathing and equipped with thermal conductivity probes, were installed in a test home. Removable wooden plugs cut from the exterior sheathing made it possible to measure any changes in the amount of absorbed moisture which migrates from inside the house. Moisture measurements began this year.

Wind Energy

Southern Alberta is one of the windiest parts of Canada, making it an ideal location to convert wind energy into electricity, or mechanical energy in the form of pumped water for irrigation, livestock watering or the creation of wetlands for waterfowl. The wind energy potential of this area has long been recognized, but in recent years there has been a renewed interest in capturing it for a variety of applications. This has given rise to a wind turbine manufacturing capability in the area that is growing steadily. The development and maturation of this industry is being aided by the Lethbridge Wind Research Test Site, an independent performance-testing facility which has been operating for more than five years.

Demonstration and Testing of Small-Scale Wind Turbines

Alberta Agriculture, Lethbridge

Since the Lethbridge Wind Research Test Site was established in 1982 to demonstrate small water-pumping wind turbines for local drainage applications, it has diversified into solar pumpers and larger wind turbines suited to a broader range of uses in developing countries.

Sales of wind turbines in Alberta and Saskatchewan have increased as a result of services provided by the test facility, and hundreds of prospective buyers visit the site annually. It is of particular value to manufacturers who might not otherwise be afforded the opportunity to test and monitor their products over long periods of time.

During the second three-year test period which concluded this year, eight wind turbines and two solar systems were monitored and evaluated. It has become apparent that long-term reliability is more important than actual water-pumping performance, and a two- or three-year test period is necessary to fully evaluate this characteristic.

Because wind turbines tested at the site have continually evolved into improved products, the industry as a whole is in a position to begin pursuing overseas markets. This requires altogether different testing circumstances because it may be necessary to pump water from depths greater than those common to western Canada. Therefore, a deep well simulator was designed, built and tested with the objective of testing all water pumpers currently on-site at various pumping heads.

This work will continue next year and include developments aimed at improving the designs of pumps and pump components, which are experiencing more failures than the turbines themselves.

At the Lethbridge Wind Research Test Site, the water-pumping performance and long-term reliability of wind turbines and solar-powered pumps continue to be monitored and evaluated.

Waste Heat Recovery/ Low Temperature Heat Utilization

In many commercial and industrial operations, heat that is produced at some stage of a process is usually released into the surroundings without any attempt to recover it. For example, heat produced by chillers and compressors in dairies, breweries and food-processing plants is discharged through exhaust gases or effluent streams. Similarly, wash water from commercial laundries is released into the sewer while still hot. In each of these cases it is possible to recover and reuse heat that would otherwise be wasted.

Also, the production of waste heat can be reduced by co-generation systems, which allow the simultaneous production of electricity and recoverable heat at a plant site or in individual buildings.

Five projects representative of these examples were investigated this year in the Waste Heat Recovery/Low Temperature Heat Utilization Subprogram.

Heat Recovery in a Full-Service Dairy

Palm Dairies Ltd., Calgary

A detailed study of hot water use in a Calgary dairy identified an opportunity to recover waste heat from the refrigeration compressor gas and use it to satisfy the entire water-heating requirements of the plant. This would avoid natural gas costs of approximately $15 000 a year.

Furthermore, electricity costs could be reduced by about $5 000 a year, and additional savings were possible from using lesser amounts of water treatment chemicals. In total, annual savings were estimated at $23 000, amounting to a simple payback period of 4.6 years for the $109 000 heat recovery system proposed for this plant.

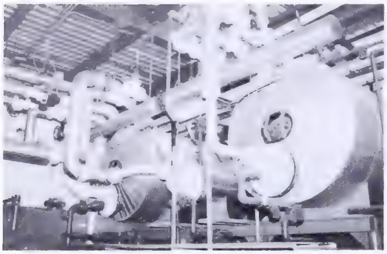
The water use survey also revealed that a new 100-tonne condenser was needed, which would not be necessary if the heat recovery system were installed.

This reduced the length of the payback period to 3.6 years. Finally, if the costs of monitoring equipment could be avoided, as would be the case in a non-demonstration project, the payback period could be as low as 2 to 2.5 years.

Before the heat recovery system was installed, however, new owners acquired Palm Dairies. They decided not to proceed with the project; therefore it was terminated.

Heat Recovery in a Meat-Packing Plant

Lakeside Feeders Ltd., Brooks



At the meat-packing plant of Lakeside Feeders Ltd., heat from refrigeration compressors is recovered and used to preheat process water. It is delivered to one of the two hot water storage tanks shown here. The heat recovery system resulted in annual natural gas savings of as much as $31 000.

(Photo courtesy of Crawford Consulting Engineering Ltd.)

Based on an energy audit of a cattle-slaughtering and meat-packing operation, which revealed that recovery of waste heat from the plant's refrigeration system could result in energy savings of 25 per cent, a heat recovery system was designed and installed in 1986. The primary purpose of the system was to reduce the amount of natural gas used to heat process water. The system comprised a condenser to recover low-grade heat and a desuperheater to recover higher-grade heat, both of which were installed in the discharge line of the refrigeration compressors.

During a 10-month monitoring period, it was observed that the recovered heat used to preheat process water before the final temperature was achieved in a natural gas-fired boiler, was sufficient to replace natural gas costing $23 000 to $31 000 annually. Installation of the system also avoided the purchase of additional condensers and improved productivity in the plant. The latter was an unexpected bonus. It was found that work stoppages caused in the past by insufficient quantities of hot water were virtually eliminated by the new system. Altogether, savings resulting from the $118 000 heat recovery system were equivalent to a payback period of 15 months.

The type of heat recovery system used in this demonstration project can be used wherever commercial processes simultaneously require hot water and refrigeration, such as in dairies, breweries and food-processing operations.

The project has been completed. One copy each of the interim and final reports is filed at the Alberta Energy Library (See Appendix B).

Grey Water Heat Recovery from Commercial Laundries

RTM Engineering Ltd., Calgary

Heat recovery systems were designed and installed at two Calgary laundries which previously had been discharging a total of 171 000 litres (38 000 gallons) of hot, grey (waste) water into the sewer from 11 industrial-sized washing machines.

The heat recovery systems allowed heat to be transferred from the waste water to cold, fresh wash water, thus displacing most of the natural gas used previously to raise the temperature of the wash water from 7°C (45°F) to 71°C (160°F).

One of the more challenging aspects of the project was to design filters to remove lint and dirt from the grey water to avoid fouling the heat exchangers.

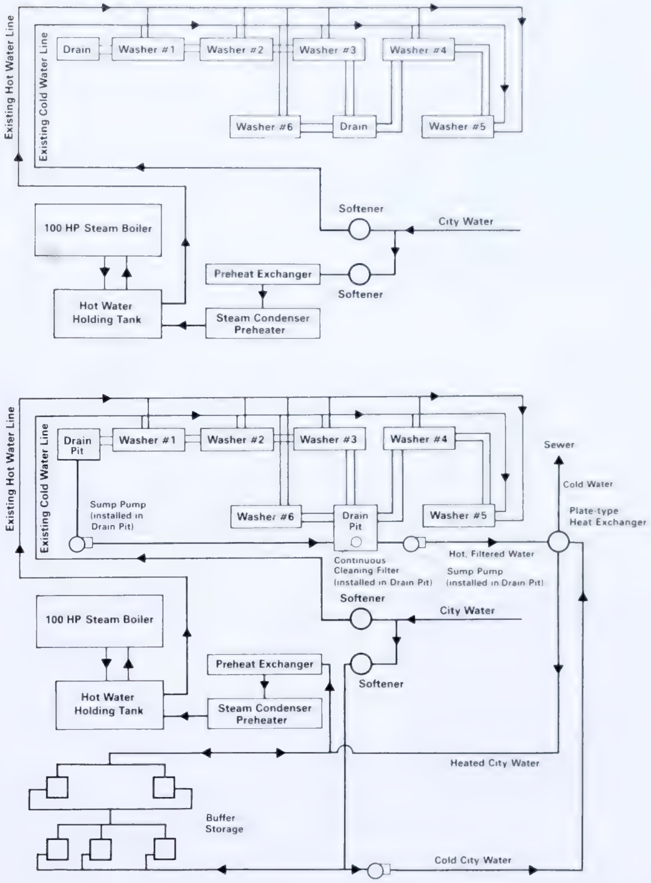
This was accompanied by other changes to the equipment and operating procedures, including reusing some of the grey water. This ultimately improved the overall operation of both plants.

During a five-week monitoring period, natural gas and water consumption were measured and compared with base conditions before installation of the heat recovery and water reuse system. At one of the plants, natural gas use declined by 38 to 50 per cent, while water consumption was reduced by 19 to 23 per cent. This amounted to annual savings of approximately $11 000, representing a payback period of five years. At the other laundry, a payback period of four years was estimated.

It was concluded that approximately $800 000 could be saved annually in Alberta if grey water heat recovery systems were used in existing commercial, hospital, hotel/motel and coin-operated laundries.

The project has been completed. One copy of the interim report is filed at the Alberta Energy Library (see Appendix B).

Schematic of a Commercial Laundry Before (top) and After (bottom) Installation of a Waste Water Heat Recovery System



(Diagrams courtesy of RTM Engineering Ltd.)

Co-generation Demonstration in Commercial Buildings

Northwestern Utilities Limited, Edmonton

This year, a 115 kW co-generator was delivered and installed at an Edmonton dry-cleaning establishment.

(Photo courtesy of Northwestern Utilities Limited)

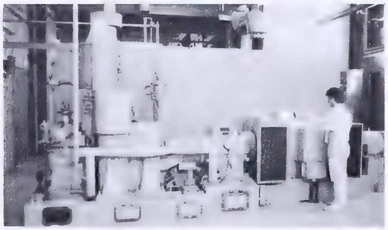
Co-generation, the simultaneous production of electric and thermal energy from a single fuel source, is capable of saving half the fuel required to produce each energy form separately. It is one energy conservation method that can be used by many owners of commercial and institutional buildings.

To demonstrate the merits of co-generation systems and those conditions under which they are practical, the energy requirements of 50 buildings within the service area of Northwestern Utilities were analysed. An Edmonton dry-cleaning firm was then selected as the site for installing a 115 kW co-generator. The selection was based on calculations which indicated that reduced energy purchases caused by the co-generator should result in a five-year payback period.

This year, the co-generator was purchased and installed. Start-up is expected in mid-1988, to be followed by one year of monitoring.

Co-generation Assessment Study

Southern Alberta Institute of Technology, Calgary



The 150 kW steam turbine at the Southern Alberta Institute of Technology was operated under co-generation conditions at various heat and electricity loads in an assessment of the cost effectiveness of co-generation in Alberta.

(Photo courtesy of Southern Alberta Institute of Technology)

In this project, the economics of co-generation are being determined under existing conditions of energy and capital costs. During the first phase of the investigation, economic assessments of a residential duplex, a restaurant and an office building indicated that payback periods of five to seven years could be anticipated if a co-generator were used in an office building. Further study revealed that co-generation is marginally cost effective in Alberta in large facilities where the thermal load follows the electrical demand.

This year, the 150 kW Gas Turbine Total Energy System at the Southern Alberta Institute of Technology was operated under co-generation conditions at various heat and electricity loads. At year-end, the contractor was assessing the data.

Energy Conservation in Industry

Since 1977, various research projects have been aimed at reducing energy consumption in Alberta's resource industries. For example, one component of a major investigation of sour gas plants dealt with strategies that could be used to save energy. Another involved the development of a cost-saving and energy-saving method of recovering helium from natural gas.

From this base grew a new subprogram, initiated this year, called Energy Conservation in Industry, which aims to develop energy-saving systems for specific industries or help individual companies capitalize on opportunities to build, sell or operate energy conservation technologies.

Recovery of Energy from Waste

Bow Valley Resource Services Ltd., Calgary

Proper disposal of municipal wastes has become one of the more vexing problems facing communities today, with little relief in sight as long as the practice of burying untreated wastes in landfills continues. As more and more communities encounter resistance to locating new landfill sites, the option of incinerating wastes and recovering heat produced in the process becomes more attractive. The feasibility of recovering such heat and using it directly or to generate electricity, is being investigated in this study, with particular emphasis on systems suitable for small communities.

So far, the investigation has revealed that energy-from-waste plants cannot be viable commercial operations in Alberta if their success depends solely on revenues from the sale of energy. However, the opportunities to use incineration in Alberta are increasing because it is becoming more difficult to find suitable sites for landfills, particularly in the Edmonton-Calgary corridor.

Consequently, the Town of Olds, which is faced with having to haul its wastes 90 km (56 miles) to Calgary, has agreed to participate in a detailed feasibility study of an energy-from-waste plant. The case study is now under way.

Hydrogen Technology Research

During the past 20 years, interest in hydrogen as a potential alternative to conventional energy resources has intensified in several countries. This activity has been spurred on by concerns about the ''Greenhouse Effect'' and the fact that clean-burning hydrogen would not contribute to this disruption in Earth's climate.

While recognizing the potential long-term use of hydrogen as a direct energy carrier or currency, there is an immediate need to use more of it in today's natural resource industry. In Alberta, for example, hydrogen is routinely used in the manufacture of fertilizers, chemicals and petrochemicals, and in processes that upgrade hydrogen-deficient energy resources such as heavy oil and oilsands bitumen. In fact, Alberta is Canada's largest producer and user of hydrogen, and its position in this regard is expected to grow as greater quantities of synthetic crude oil must be produced to replace declining supplies of conventional oil.

As demand for hydrogen grows, more-efficient and cost-effective technologies will be needed for its manufacture, purification, storage and distribution. This will require significant research on the part of industries, governments and academic institutions. To help launch this work, a Hydrogen Technology Research Program was initiated this year.

Hydrogen Technology Inventory Study for Alberta

RTM Engineering Ltd., Calgary

To ascertain the existing gaps and current priorities of hydrogen research and development in Alberta, an inventory was made of major hydrogen producers, users and research agencies.

The survey revealed that current production, use and research are primarily concerned with resource development or enhancement, but it also showed that hydrogen is used in other industries. It is expected that hydrogen's role in all sectors will become even more important in the future.

In attempting to determine which research areas are most important, it was apparent that natural resource enhancement must be regarded as the first priority, with the greatest need being bitumen/heavy crude oil upgrading.

This is made imperative by the belief that supplies of crude oil from conventional sources will decline sharply in the 1990s, leaving synthetic crude oils or upgraded heavy oils to fill the supply gap.

Also regarded as important, but of lower priority, is research related to coal gasification and coal/bitumen co-processing. One potential source of needed hydrogen might evolve from processes that dissociate hydrogen sulphide into hydrogen and sulphur.

From this survey, a list of prospective research projects was prepared for discussion by government and industry representatives, who were to launch research investigations within the Hydrogen Technology Research Program in the summer of 1988.

Technology Transfer

Since the Alberta/Canada Energy Resources Research Fund was established, it has provided financial support to approximately 200 energy research projects. This includes studies of conventional energy resources, coal, energy conservation and renewable energy.

In 1986, it was decided that a series of technology transfer booklets would be introduced to provide summaries of these studies and permit wide distribution of the research results. This service is provided on contract.

Technology Transfer and Dissemination

MacKenzie Environmental Consultants Ltd., Edmonton

The principal findings of approximately 60 energy conservation and renewable energy research projects are being summarized and published in a series of technology transfer booklets.

Fourteen booklets covering 34 projects have been published thus far, and were distributed to more than 300 energy researchers, government agencies, energy companies and technical libraries.

The following publications are available from:

Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Bramalea Building
9920 - 108 Street
Edmonton, Alberta
T5K 2M4
Telephone: (403) 427-3590

and

Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Britannia Building
703 - 6th Avenue S.W.
Calgary, Alberta
T2P 0T9
Telephone: (403) 297-6324

Solar Energy Potential for Alberta, 9 pages, March 1986.

A Practical Method for Defouling Heat Exchangers, 6 pages, March 1986.

Development of a Krypton Fluoride Laser for Fusion Energy Research, 6 pages, July 1986.

Geothermal Energy Resources in Alberta, 10 pages, August 1986.

Measuring and Harnessing Alberta's Wind Resources, 10 pages, October 1986.

Energy Management in Commercial Buildings, 8 pages, December 1986.

Control of Heat Loss Associated with Overhead Doors, 6 pages, January 1987.

Practical Methods to Seal and Insulate Residential Buildings, 9 pages, March 1987.

Performance Characteristics of Energy-Efficient Residential Furnaces, 9 pages, April 1987.

Energy-Conserving Characteristics of Common Building Materials and Methods, 14 pages, April 1987.

Some Methods of Insulating Basements, Walls and Windows, 10 pages, July 1987.

Development of Delta-Blade Wind Turbines, 10 pages, September 1987.

A Programmable Controller for Parking Lot Block Heaters, 9 pages, March 1988.

Some Methods of Saving Energy with Fluorescent Lighting, 8 pages, March 1988.

Appendices

Financial information on this year's projects, as well as sums expended to date on all A/CERRF-funded energy conservation and renewable energy projects, can be found in Appendix A.

Research reports that have resulted from some of these investigations, and are available for viewing at Alberta Energy's library in Edmonton, are listed in Appendix B.

Appendix A: Summary of Program Expenditures

A/CERRF Energy Conservation and Renewable Energy Projects and Expenditures to Date ($)

Subprogram Area and Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	Total Current Funding Contribution	Projected Total Funding Contribution
General Energy Conservation													
Control of Energy Losses by Microbial Fouling of Heat Exchangers	-	23 768	67 628	3 999	-	-	-	-	-	-	-	95 395	95 395
Ice Nucleation Technique for Defouling of Heat Exchangers	-	-	-	-	75 459	4 799	-	-	-	-	-	80 258	80 258
Using Thermal Discharges from Power Plants	-	9 653	5 347	-	-	-	-	-	-	-	-	15 000	15 000
Fuel and Fertilizer Production from Dairy Manure	-	6 176	17 148	-	-	-	-	-	-	-	-	23 324	23 324
Efficient Use of Low Heating Value Fuels	-	-	11 984	32 064	15 772	-	-	-	-	-	-	59 820	59 820
Streamline Device for Transport Trucks	-	-	665	5 995	2 256	-	-	-	-	-	-	8 916	8 916
Energy from Waste Wood (Sawmill Residues)	89 094	7 917	15 844	1 646	-	-	-	-	-	-	-	114 501	114 501
Efficiency of Rotary Piston Engine	9 213	2 644	-	-	-	-	-	-	-	-	-	11 857	11 857
District Heating Study	-	66 394	33 606	(6 600)	-	-	-	-	-	-	-	93 400	93 400
Energy Conservation in Sour Gas Processing	146 927	196 536	268 323	97 256	209 532	34 963	93 637	131 400	-	-	-	1 178 574	1 178 574
Subtotal – General Energy Conservation	**245 234**	**313 088**	**420 545**	**134 360**	**303 019**	**39 762**	**93 637**	**131 400**	**0**	**0**	**0**	**1 681 045**	**1 681 045**
Solar Energy													
Copper-Oxide Solar Cells	-	8 404	20 466	-	-	-	-	-	-	-	-	28 870	28 870
An Atlas of Solar Energy for Alberta	-	-	23 730	17 884	3 015	-	-	-	-	-	-	44 629	44 629
Application of Boiling and Condensation Heat Transfer for Flat Solar Collectors in Cold Regions	-	-	27 237	33 359	25 627	12 977	-	-	-	-	-	99 200	99 200
An Air-Mediated Solar Heating System with Long-Term Storage	-	-	15 706	26 907	-	-	-	-	-	-	-	42 613	42 613
An Advanced Control Approach for Solar Heating Systems	-	-	-	-	10 219	3 621	-	-	-	-	-	13 840	13 840
Subtotal – Solar Energy	**0**	**8 404**	**87 139**	**78 150**	**38 861**	**16 598**	**0**	**0**	**0**	**0**	**0**	**229 152**	**229 152**
Geothermal Energy													
Research on Alberta's Geothermal Energy Resources	-	18 063	43 286	75 298	60 399	83 704	57 463	-	-	-	-	338 213	338 213
Fusion Energy													
Laser Fusion Energy Research	-	5 784	56 111	122 995	144 855	152 927	146 987	-	-	-	-	629 659	629 659
Energy Conservation in Buildings													
Alberta Home Heating Research Facility	-	2 825	142 705	44 740	33 990	19 524	-	-	-	-	-	243 784	243 784
Insulation Properties of Flat Built-up Roofs	-	19 268	6 584	13 930	8 176	7 980	-	-	-	-	-	55 938	55 938
Passive Solar-Heated Community Centre	-	-	-	2 050	10 120	2 000	-	-	-	-	-	14 170	14 170
Energy-Efficient Masonry Fireplaces	-	-	-	-	-	48 820	-	-	-	-	-	48 820	48 820
Edmonton Energy Conservation Centre	-	-	-	-	-	-	-	51 920	25 000	-	-	76 920	76 920
Self-Help Retrofit Manual for Owners of Multi-Family Housing Units	-	-	-	-	-	-	1 745	12 805	10 850	-	-	25 400	25 400

Subprogram Area and Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	Total Current Funding Contribution	Projected Total Funding Contribution
Retrofit Wall Systems for Residential Housing	-	-	-	-	-	-	342	2 540	6 998	-	-	9 880	9 880
Energy Savings and Payback of Retrofit Basement Wall Insulation	-	-	-	-	-	-	506	8 435	3 883	-	-	12 824	12 824
Energy-Efficient Housing Display Program	-	-	-	-	221 332	3 614	3 384	2 650	-	3 020	-	234 000	234 000
Townhouse Retrofit Demonstration	-	-	-	-	-	-	6 477	11 049	2 514	-	-	20 040	20 040
A Survey of Air Leakage in Alberta Homes	-	-	-	-	-	-	15 709	40 071	4 376	-	-	60 156	60 156
Construction and Testing of a Masonry Module	-	-	-	-	-	-	9 931	15 237	5 896	-	-	31 064	31 064
Concrete Masonry Walls for Thermal Storage, Heating and Insulation	-	-	-	-	-	-	5 860	10 440	(1 630)	-	-	14 670	14 670
Computer Program for Analysis of Thermal Mass	-	-	-	-	-	-	-	-	24 314	1 641	-	25 955	25 955
Sizing of Warm Air Furnaces for Residential Use	-	-	-	-	-	-	3 192	127	-	-	-	3 319	3 319
Development of Higher-Efficiency Gas-Fired Furnaces	-	-	-	-	-	-	4 376	35 624	30 000	-	-	70 000	70 000
Seasonal Efficiency of Residential Natural Gas Furnaces	-	-	-	-	-	-	-	20 261	12 738	1 190	-	34 189	34 189
Development of an Insulating Curtain for Residential Installation	-	-	-	-	-	-	8 047	25 917	-	-	-	33 964	33 964
Residential Air-to-Air Heat Exchanger Using Heat Pipe Technology	-	-	-	-	-	-	943	5 968	4 192	1 448	-	12 551	12 551
Energy Conservation in Public Swimming Pools	-	-	-	-	-	-	9 969	20 236	1 635	-	-	31 840	31 840
Development of a User-Friendly Computerized Building Management System	-	-	-	-	-	-	4 928	37 281	26 914	477	-	69 600	69 600
Multi-Zone Setback Thermostat	-	-	-	-	-	-	8 359	28 553	4 048	-	-	40 960	40 960
A New Heat-Conserving Control System for Warehouse-Type Buildings	-	-	-	-	-	-	3 538	17 782	9 654	-	-	30 974	30 974
Demonstration of a Cost-Effective Energy Management System	-	-	-	-	-	-	8 427	8 359	-	-	-	16 786	16 786
A Ventilation Control System Based on Carbon Dioxide Levels	-	-	-	-	-	-	604	750	-	-	-	1 354	1 354
Inventory of Building Design and Analysis Computer Programs and a Weather Input Data Base for Alberta	-	-	-	-	-	-	1 484	36 063	-	-	-	37 547	37 547
Energy-Efficient Fluorescent Lighting Ballast	-	-	-	-	-	-	19 565	30 371	-	-	-	49 936	49 936
Computer Simulations for Mechanical Systems in Buildings	-	-	-	-	-	-	8 886	27 885	11 538	-	-	48 309	48 309
Programmable Controller for Parking Lot Block Heater Service	-	-	-	-	-	-	-	-	7 554	2 868	-	10 422	10 422
Comprehensive Retrofit Measures in Commercial Buildings	-	-	-	-	-	-	-	-	14 552	-	-	14 552	14 552
Retrofit Curtain for Overhead Doors	-	-	-	-	-	-	-	-	13 656	3 493	-	17 149	17 149
Demonstration of Mini-Fluorescent Lighting	-	-	-	-	-	-	-	-	2 700	3 235	-	5 935	5 935

Subprogram Area and Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	Total Current Funding Contribution	Projected Total Funding Contribution
Survey of Energy-Efficient Furnaces	-	-	-	-	-	-	-	-	20 282	14 167	-	34 449	34 449
Swimming Pool Dehumidification Demonstration	-	-	-	-	-	-	-	-	4 700	20 234	987	25 921	27 700
Peak Electrical Demand Reduction Through Co-generation	-		-	-	-	-	-	-	5 745	8 376	5 183	19 304	31 636
Demonstration of Free Cooling in Building Humidification Systems	-	-	-	-	-	-	-	-	2 600	15 323	6 988	24 911	33 570
Demonstration of Low Emissivity Ceilings in Alberta Arenas	-	-	-	-	-	-	-	-	8 102	28 517	2 229	38 848	38 848
Energy Conservation in Housing	-	-	-	-	-	-	-	-	-	-	77 786	77 786	206 000
Subtotal – Energy Conservation in Buildings	**-**	**22 093**	**149 289**	**60 720**	**273 618**	**81 938**	**126 272**	**450 324**	**262 811**	**103 989**	**93 173**	**1 624 227**	**1 775 211**
Wind Energy													
Comparison of Wind Turbines	-	-	-	-	10 686	14 310	-	-	-	-	-	24 996	24 996
Demonstration and Testing of Small-Scale Wind Turbines	-	-	-	-	-	72 386	47 324	34 408	61 974	46 938	39 996	303 026	411 026
Solar and Wind Energy Research	131 731	539 332	310 813	256 673	334 809	233 699	254 195	237 605	187 681	-	-	2 486 538	2 486 538
A Large Delta-Blade Wind Turbine, An Alberta Development	-	-	-	-	92 945	170 400	477 772	35 294	108 222	39 778	-	924 411	924 411
Subtotal – Wind Energy	**131 731**	**539 332**	**310 813**	**256 673**	**438 440**	**490 795**	**779 291**	**307 307**	**357 877**	**86 716**	**39 996**	**3 738 971**	**3 846 971**
Waste Heat Recovery/Low Temperature Heat Utilization													
Grey Water Heat Recovery from Commercial Laundries	-	-	-	-	-	-	-	-	36 906	72 949	-	109 855	109 855
Heat Recovery in a Recreation Facility	-	-	-	-	-	-	-	-	5 707	-	-	5 707	5 707
Heat Recovery in a Meat-Packing Plant	-	-	-	-	-	-	-	-	14 089	47 956	8 534	70 579	70 579
Heat Recovery in a Full-Service Dairy	-	-	-	-	-	-	-	-	12 912	1 267	-	14 179	14 179
Co-generation Demonstration in Commercial Buildings	-	-	-	-	-	-	-	-	1 267	12 098	50 756	64 121	105 861
Co-generation Assessment Study	-	-	-	-	-	-	-	-	14 758	16 244	40 827	71 829	80 000
Utilization of Waste Heat for Crop Production	-	-	-	-	-	-	-	-	16 395	-	-	16 395	16 395
Subtotal–Waste Heat Recovery/Low Temperature Heat Utilization	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**102 034**	**150 514**	**100 117**	**352 665**	**402 576**
Energy Conservation in Industry													
Recovery of Energy from Waste	-	-	-	-	-	-	-	-	-	-	42 568	42 568	119 800
Hydrogen Technology													
Hydrogen Inventory Study for Alberta	-	-	-	-	-	-	-	-	-	-	47 874	47 874	47 874
TOTAL – Energy Conservation and Renewable Energy	**376 965**	**906 764**	**1 067 183**	**728 196**	**1 259 192**	**865 724**	**1 203 650**	**889 031**	**722 722**	**341 219**	**323 728**	**8 684 374**	**9 070 501**
Technology Transfer													
Technology Transfer and Dissemination	-	-	-	-	-	-	-	-	-	82 144	69 917	152 061	373 061
TOTAL	**376 965**	**906 764**	**1 067 183**	**728 196**	**1 259 192**	**865 724**	**1 203 650**	**889 031**	**722 722**	**423 363**	**393 645**	**8 836 435**	**9 443 562**

Appendix B: Publications List

The following project reports, prepared by contractors whose investigations were supported by A/CERRF, are available for viewing at:

Alberta Energy Library
9th Floor, South Tower, Petroleum Plaza
9915 - 108 Street
Edmonton, Alberta
T5K 2C9

Telephone: (403) 427-7425

General Energy Conservation

Thermal Power Plant Waste Heat Utilization in Alberta: Potential and Problems, F.B. MacKenzie and A.H. Laycock, University of Alberta, 1979.

Fuel and Fertilizer Production from Dairy Manure, J.J.R. Feddes, J.B. McQuitty and J.T. Ryan, University of Alberta, March 1980.

The Efficient Utilization of Low Heating Value Fuels, G.A. Karim, University of Calgary, January 1982.

A Streamline Device for Trucks and Buses, R.P. McKenzie, 1982.

Claus Plant Waste Gas Incinerators, Western Research and Development, July 1978.

Capability of the Modified Claus Process, H.G. Paskall, Western Research and Development, 1979.

Catalytic Incineration of Sulphur Plant Waste Gases, Bow Valley Research Ltd., February 1981.

Recuperative Heat Exchange Incinerator Pilot Plant, Bow Valley Research Ltd., October 1981.

Study on Energy and Chemicals from Wood, SNC Tottrup Services Ltd., 1979.

Edmonton District Heating Study — Financial Feasibility, Stanley Associates Engineering Ltd./Ekono Engineering Consultants, February 1980.

An Energy Audit Strategy for Gas Plants, Bow Valley Research Ltd., June 1985.

Solar Energy

A Solar Energy Atlas for Alberta, Volumes I and II, L.C. Nkemdirim, University of Calgary, September 1981.

Application of Boiling and Condensation Heat Transfer to Flat Plate Solar Collectors in Cold Regions, K.C. Cheng, University of Alberta, August 1982.

Study of Air-Mediated Solar Heating Systems with Long-Term Storage, A.M. Robinson, University of Alberta, April 1981.

A Study of Improved Control Strategies for Bilinear Heat Transfer Processes in a Solar-Assisted Heat Pump System, R.E. Rink and H.Q. Le, University of Alberta, October 1982.

Solar and Wind Energy Research Program (SWERP) Information Centre, Alberta Research Council, March 1986.

Geothermal Energy

An Investigation of Geothermal Energy Resources of Alberta, F.W. Jones, H.L. Lam and T.N. Nasr, University of Alberta, October 1981.

A Detailed Study of Regions of Geothermal Energy Potential in Alberta, F.W. Jones, H.L. Lam, M. Rahman and D. Yuen, University of Alberta, October 1982.

A Preparatory Study for Application of Geothermal Energy in the Hinton/Edson Area of Alberta, F.W. Jones, M. Rahman, H.L. Lam and J.E. Sworder, University of Alberta, October 1983.

Fusion Energy

CO_2 Laser-Heated Solenoid Research and High Power Krypton Fluoride Laser Development for Fusion Energy Research, A.A. Offenberger, D.C.D. McKen and R. Fedosejevs, University of Alberta, May 1981.

High Power Krypton Fluoride Laser Development for Fusion Energy Research, A.A. Offenberger, D.C.D. McKen and R. Fedosejevs, University of Alberta, May 1983.

Energy Conservation in Buildings

Construction of the Alberta Home Heating Research Facility and Results for the 1979-1980 Heating Season, R.R. Gilpin, J.D. Dale, T.W. Forest and M.Y. Ackerman, University of Alberta, August 1980.

Second Annual Report on the Alberta Home Heating Research Facility: Results for the 1980-81 Heating Season, R.R. Gilpin, T.W. Forest, M.Y. Ackerman, D.G. Wilson, G.W. Sadler, J.D. Dale and M. Zaheeruddin, University of Alberta, June 1981.

A Simulation Model for a Direct Gain Passive House and its Experimental Verification, M. Zaheeruddin, University of Alberta, April 1983.

A Study of Residential Housing Envelope Heat Losses, M.Y. Ackerman, University of Alberta, April 1983.

Thermal Performance of an Insulated Masonry Structure: Results of the 1983-84 Heating Season, L.W. Kostiuk and J.D. Dale, October 1984.

The Attachment of Insulation to Existing Built-Up Roofs, Alberta Roofing Contractors, August 1981.

A Project to Build and Display Energy-Efficient Single Family Homes in Alberta, HUDAC Alberta Council, November 1982.

Report on the Selection of Warm Air Furnaces for Residential Housing, J.E. Sworder Engineering, November 1984.

Report on Inventory of Computer Programs, Vinto Engineering Ltd., December 1984.

Report on Development of an Alberta Weather Input Data Base, Vinto Engineering Ltd., February 1985.

R&D of an Insulating Curtain for Residential Application, Sunergy Systems Ltd., April 1985.

The Edmonton Energy Conservation Centre — Phase I Retrofit, Tomorrow Foundation, May 1985.

Edmonton Energy Conservation Centre, Phase II Final Report, Brian Staszenski, March 1986.

Technical Feasibility and Cost Study of Programmable Controller for Parking Lot Block Heater Services, Magna IV Engineering Ltd., November 1985.

Programmable Controller for Parking Lot Block Heater Services, Magna IV Engineering Ltd., March 1986.

Demonstration of Low Emissivity Ceilings in Arenas, Phase I, Sunton Engineering Ltd., April 1986.

Demonstration of Low Emissivity Ceilings in Arenas, Phase II, Sunton Engineering Ltd., September 1986.

A Survey of Air Leakage in Calgary Homes, Bill Johnston Architect Ltd., April 1986.

A Study of the Performance of Six Residential Natural Gas Furnaces, J.F. Kasha and J.D. Dale, University of Alberta, May 1986.

Cost-Effective Energy Management System, Whitaco Holdings Ltd., June 1986.

Survey of Medium- and High-Efficiency Gas Furnaces, W.J. Mayhew and D.G. Howell, Howell Mayhew Engineering Inc., December 1986.

Development of a Computer Program for Analysis of Thermal Mass in Buildings, A.P. Byrne and T.G. Lee, University of Calgary, December 1986.

Energy Savings and Payback with Basement Wall Insulation Retrofit, D.S. Greeley, Dow Chemical Canada Inc., December 1986.

Retrofit Wall System for Residential Housing, J. Ostrowski and H. Ostrowski, ARE – Alternative and Retrofit Energies Inc., January 1987.

Residential Air-to-Air Heat Exchanger Using Heat Pipe Technology, P.G. Williams and C.T. Grusendorf, EMC Energy Management Consultants Ltd., May 1987.

Demonstration of Minifluorescent Lighting: Phase II, J.A. Love, March 1987.

Wind Energy

Evaluation of Low Volume Wind Turbines for Pumping Water, B.A. Paterson, D.R. Baker and N.E. Jensen, 1985.

Comparison Study of Wind Turbines, The Dalcor Group, April 1982.

Survey of Wind Turbine Installations in Alberta in 1981, D.R. Baker, DRB Engineering Consultants Ltd., April 1986.

Performance Test Results of the Deltx WP50 Windpump Prototype, D.R. Baker, DRB Engineering Consultants Ltd., September 1986.

Lethbridge Wind Research Test Site Evaluation of Wind and Solar Pumping Systems, 1985-1987, B.A. Paterson, D.R. Baker and N.E. Jensen, 1988.

Waste Heat Recovery

Waste Heat Recovery in a Meat-Packing Plant, Phase I, Crawford Consulting Engineering Ltd., December 1985.

Heat Recovery in a Meat Packing Plant: Phase II, Crawford Consulting Engineering Ltd., December 1985.

Heat Recovery in a Meat Packing Plant — Final Report, Crawford Consulting Engineering Ltd., October 1987.

Grey Water Waste Heat Recovery in Commercial Laundries: Phase I, Adept Engineering, February 1986.

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Detailed information on any project funded by the Alberta/Canada Energy Resources Research Fund is available from:

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